α-Pinene and ethanol: Key host volatiles for *Xylotrechus longitarsis* (Coleoptera: Cerambycidae)

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ABSTRACT

Xylotrechus longitarsis Casey is a common wood-boring beetle that causes considerable losses to the softwood lumber industry in British Columbia. Trapping experiments were conducted in the southern interior of British Columbia to determine whether the generic bait of α-pinene plus ethanol is an optimal combination for attraction of *X. longitarsis*. α-Pinene alone attracted substantial numbers of *X. longitarsis* and trap catches were increased significantly with the addition of ethanol lures but different release rates of ethanol had no significant effect. The blend of pure α-pinene and ethanol was significantly more attractive than more complete blends of conifer monoterpenes and ethanol, whether or not α-pinene was a major component of the blend. Strong attraction to α-pinene reflects the preference of *X. longitarsis* for conifers, and particularly Douglas-fir, *Pseudotsuga menziesii* (Mirbel) Franco, the bark of which is relatively rich in α-pinene. Increased attraction with the addition of ethanol lures, irrespective of release rates, to traps baited with α-pinene suggests that *X. longitarsis* prefers severely stressed hosts or deteriorating host material but may also utilize freshly cut or broken material.

Key words: *Xylotrechus longitarsis*, Cerambycidae, chemical ecology, host volatiles, woodborers, pest management, trapping

INTRODUCTION

Xylotrechus longitarsis Casey is a coniferophagous wood-boring beetle that is common and widespread in British Columbia (BC), ranging east into Alberta and south to Colorado and northern California (Linsley 1964). The flight period is reported as May to August

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(Linsley 1964) but adults may be abundant well into September in the southern interior of BC, where this species is usually the most numerous of the large wood-boring insects (Cerambycidae, Buprestidae, Siricidae) captured around log storage areas (McIntosh *et al.* 2001; Morewood *et al.* 2002). The relative abundance of *X. longitarsis* suggests that it is a major contributor to the estimated $43.6 million (US) in annual degrade losses to the softwood lumber industry caused by large woodborers in the interior of BC (Phero Tech Inc. 1997).

Wood-boring insects are pests of timber destined for lumber production, attacking and degrading dead or dying trees and logs after harvest but before processing. Management of large woodborers has been limited primarily to a strategy of preventing attack through rapid utilization, peeling, water sprinkling, or storage of logs in water or in compact decks with maximum shading (Safranyik and Moeck 1995), with operational trapping programs currently under development. In contrast, prevention of attack by ambrosia beetles (Coleoptera: Scolytidae) is accomplished in part through well-established trapping programs using semiochemical-baited traps (Borden 1995). Various combinations of host monoterpenes and ethanol are attractive to coniferophagous cerambycids (Ikeda *et al.* 1980; Fatzinger *et al.* 1987; Phillips *et al.* 1988), with some evidence that α-pinene is the most attractive of individual monoterpenes tested (Ikeda *et al.* 1986; Chénier and Philogène 1989). Currently, the simple combination of α-pinene and ethanol is used provisionally as a generic bait for trapping large woodborers in BC. However, this blend does not replicate the complex mixture of host-associated chemical cues that could be used by these insects during host selection. Our objective was to determine whether more complete blends of conifer volatiles, primarily monoterpenes and ethanol, would be more attractive to *X. longitarsis* than pure α-pinene and ethanol.

MATERIALS AND METHODS

Different combinations of host volatiles were tested as baits in 12-unit multiple funnel traps (Lindgren 1983) suspended from metal poles with the top funnel about 1.5 m above ground. Captured insects were frozen until they could be sorted and counted.

To test whether ethanol is important in attracting *X. longitarsis* and whether such attraction is affected by release rate, an experiment was superimposed on operational trapping programs around the log storage yard at Gorman Bros. Ltd. in Westbank and the Riverside Forest Products Ltd. 4-Mile dryland log sort and Okanagan Lake log dump, both on the Bear Forest Service Road west of Kelowna. Traps were baited with α-pinene [96% (–) enantiomer, > 99% chemical purity, released at 2.2 g/d; Phero Tech Inc., Delta, BC] alone or combined with either low-release (30-50 mg/d) or high-release (1.8 g/d) ethanol lures in randomized complete blocks on 2 September 1999. Insects were collected from nine blocks of traps on 10 September 1999 and 12 blocks of traps on 17 September 1999, for a total of 21 replicates.

To test whether α-pinene is an adequate host-recognition cue for *X. longitarsis*, compared to more complete blends of conifer monoterpenes, two experiments were conducted in a small clearcut 8.3 km up the Laluwissen Forest Service Road north of Lytton. The surrounding forest was predominantly Douglas-fir, *Pseudotsuga menziesii* (Mirbel) Franco, with some lodgepole pine, *Pinus contorta* Douglas ex Loudon, and ponderosa pine, *Pinus ponderosa* P. & C. Lawson. In each experiment, catches in traps baited with a blend of host volatiles distilled from lodgepole pine turpentine (H.D. Pierce Jr., Department of Biological Sciences, Simon Fraser University, unpublished data) were compared to catches in traps baited with pure α-pinene (as above, release rate 150 mg/d) and to catches in unbaited traps, deployed in 10 randomized complete blocks. Both host blends and α-pinene were combined with low-release ethanol lures. In the first experiment, traps were baited with a modified host blend (released at 750 mg/d), with β-phellandrene enriched and α-pinene nearly eliminated (Table 1), on 1 August 2001 and insects were collected on 14 August 2001. In the second experiment, traps were baited with a natural host blend (released at 700 mg/d), distilled without greatly altering the relative proportions of major components (Table 1), on 28 August 2001. Insects were collected on 11 September 2001 and the treatments were re-randomized to minimize position effects. Insects were collected again on 23 September 2001 to compensate for the declining catches later in the season, and the two collections were combined for a total of 10 replicates.

Table 1

Composition of "natural" and "modified" host blends distilled from lodgepole pine turpentine and used in trapping experiments for *Xylotrechus longitarsis*.

Compound	Enantiomeric composition (%)		Percent of host blend	
	(+)	(–)	Natural	Modified
α-pinene	44	56	18.4	0.9
β-pinene	0	100	16.6	4.4
3-carene	100	0	23.6	24.8
limonene	42	58	3.8	7.8
β-phellandrene	0	100	28.0	51.0
unidentified minor components	n.a.	n.a.	9.6	11.1

Data were transformed by $\log(x + 1)$ to correct for non-normality and heteroscedasticity (Thöni 1967; Zar 1999) and then subjected to analysis of variance (PROC ANOVA) for randomized complete blocks (Kvanli 1988; SAS Institute Inc. 1999). Means were compared using the Ryan-Einot-Gabriel-Welsch (REGWQ) multiple range test (Day and Quinn 1989; SAS Institute Inc. 1999).

RESULTS

Traps baited with α-pinene plus ethanol captured significantly greater numbers of *X. longitarsis* than traps baited with α-pinene alone ($F_{2,40} = 5.89$, $P = 0.0057$), but trap catches did not differ significantly between traps with ethanol released at high or low rates (Fig. 1).

Traps baited with α-pinene plus ethanol captured significantly greater numbers of both sexes of *X. longitarsis* than traps baited with ethanol plus either the modified host blend ($F_{2,18} = 16.06$, $P < 0.0001$ for males; $F_{2,18} = 38.06$, $P < 0.0001$ for females) or the natural host blend ($F_{2,18} = 19.82$, $P < 0.0001$ for males; $F_{2,18} = 11.54$, $P = 0.0006$ for females). Traps baited with either host blend captured significantly greater numbers of males, but not females, than unbaited traps (Fig. 2).

DISCUSSION

The simple combination of α-pinene and ethanol appears to be particularly well-suited for attracting *X. longitarsis*, reflecting both host preferences and considerable flexibility with respect to suitable host material. The only host association published for *X. longitarsis* is Douglas-fir (Linsley 1964) and most of the reared specimens in the insect collection at the Pacific Forestry Centre, Victoria, BC, are from Douglas-fir. α-Pinene is the dominant monoterpene in Douglas-fir bark (D.S. Pureswaran, Department of Biological Sciences, Simon Fraser University, unpublished data) and is thought to be the primary attractant for the Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopkins (Coleoptera: Scolytidae) (Heikkenen and Hrutfiord 1965).

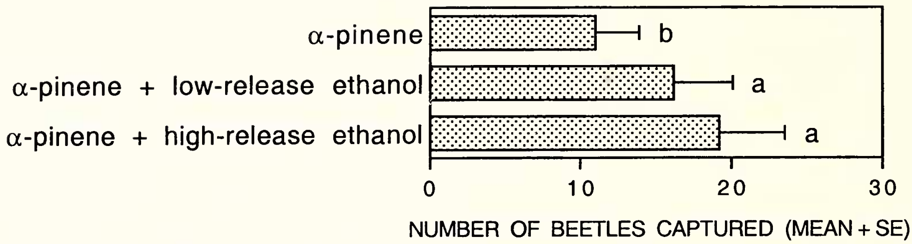

Figure 1. Catches of *Xylotrechus longitarsis* at three locations in the central Okanagan Valley, BC, 2-17 September 1999 in traps baited with α-pinene (released at 2.2 g/d) alone or combined with either low-release (30-50 mg/d) or high-release (1.8 g/d) ethanol lures. The difference between the bars with the same letter is not statistically significant (REGWQ, $P > 0.05$).

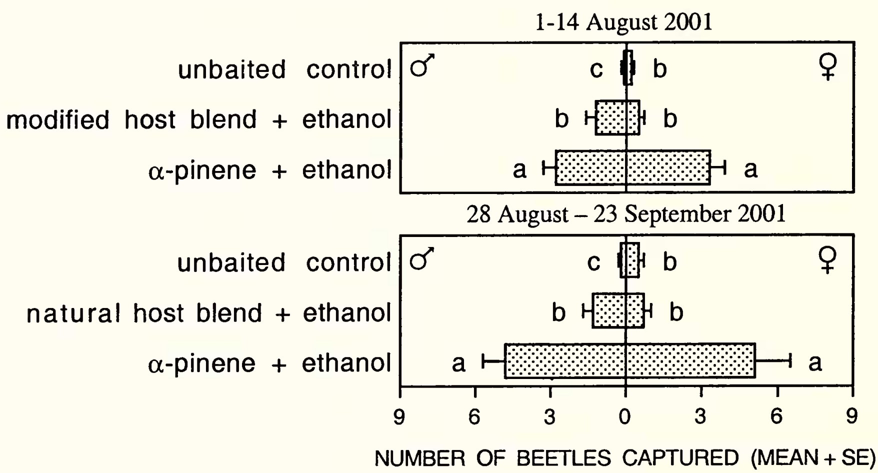

Figure 2. Catches of *Xylotrechus longitarsis* near Lytton, BC, in August and September 2001 in traps baited with a modified (above) or natural (below) host blend (released at 750 mg/d or 700 mg/d, respectively) or α-pinene (released at 150 mg/d), each combined with ethanol (released at 30-50 mg/d), or unbaited. For a given time period and sex, differences between bars with the same letter are not statistically significant (REGWQ, $P > 0.05$).

On the other hand, the geographic range of *X. longitarsis* extends beyond that of Douglas-fir and other conifer species can serve as hosts. We have reared *X. longitarsis* in ponderosa pine bolts and there are specimens in the insect collection at the Pacific Forestry Centre reared from logs of lodgepole pine, western hemlock, *Tsuga heterophylla* (Rafinesque-Schmaltz) Sargent, western larch, *Larix occidentalis* Nuttall, and white spruce, *Picea glauca* (Moench) Voss. Despite this apparent broad acceptability of different conifer hosts, including lodgepole pine, monoterpene blends derived from lodgepole pine were significantly less attractive than pure α-pinene (Fig. 2). Furthermore, this lack of attraction was not simply due to the lack of α-pinene in the modified host blend because the natural host blend, which contained a substantial amount of α-pinene (Table 1) and released it at a rate of 129 mg/d (compared to 150 mg/d for the pure compound), was no more attractive relative to pure α-pinene than the modified host blend (Fig. 2). Coupled gas chromatographic – electroantennographic detection analyses indicate that the antennae of *X. longitarsis* can detect each of the five prominent monoterpenes listed in Table 1 (R.

Gries, Department of Biological Sciences, Simon Fraser University, unpublished data). These considerations suggest that some component of these natural host blends is either repellent to *X. longitarsis* or interferes with the response to α-pinene.

Like many cerambycid species that breed in severely stressed hosts (Hanks 1999), adult *X. longitarsis* are attracted to recently felled trees and cut logs. Ethanol is a primary attractant for other species that breed in recently felled trees and cut logs, such as the ambrosia beetles *Gnathotrichus sulcatus* LeConte and *Trypodendron lineatum* (Olivier) (Cade *et al.* 1970; Moeck 1970), and might be considered a general indicator of stress in trees (Kimmerer and Kozlowski 1982; Kelsey and Joseph 1998). Cut or broken conifers initially release large amounts of monoterpenes, with gradually increasing amounts of ethanol as the material deteriorates, and many bark and ambrosia beetles and their associates are attracted to ratios of α-pinene and ethanol that reflect the condition of host material to which each species is adapted (Schroeder and Lindelöw 1989). In contrast, *X. longitarsis* would appear to accept host material in a broad range of conditions, considering the similarity of catches in traps with very different release rates of ethanol and the substantial catches even in traps baited with α-pinene alone (Fig. 1).

For operational trapping, the simple combination of α-pinene and ethanol appears to be optimal for attracting *X. longitarsis* and also has economic and practical advantages over more complete monoterpene blends. A lure containing a single compound is likely to be less expensive than one with a more complex blend and α-pinene is more easily purified than other conifer monoterpenes (H.D. Pierce Jr., personal communication). In addition, blends containing large amounts of β-phellandrene are unpleasant to work with because β-phellandrene is unstable and tends to polymerize on the outside of the lures as it is released, creating a sticky mess.

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